# Space Weather Technical Forecast

Issued on Monday, 11 December 2023 at 00:27 Local

**This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales**

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**Space Weather Forecast Headline: Further isolated M-flares likely.**

**Analysis of Space Weather Activity over past 24 hours**
**Solar Activity:** Solar activity has been Moderate, with the peak flare M2.3 at 10/0353 UTC from AR3511 in the southwest, which is the most active region. It is nearing the southwest limb and is becoming increasingly difficult to analyse. Although significant magnetic complexity can no longer be seen, there have been recent alterations in the shape of the leading spot and the activity level suggests some complexity. AR3513 at north centre disc evolves slowly, with small changes in the numerous, mixed polarity spots that occupy the intermediate part of the group. In total there are currently nine sunspot regions on the disc, however all other regions are currently relatively small and simple at the present time.
No Earth-directed CMEs were observed in available imagery.

**Solar Wind / Geomagnetic Activity:** Solar winds as observed by ACE and DSCOVR at L1 were at ambient levels. Wind speeds were around 350km/s, with below average density. Total Interplanetary Magnetic Field (Bt) was weak, below 5nT, while the north-south component (Bz) varied weakly. Phi angle was predominately negative (towards the Sun). Geomagnetic activity was Quiet (Kp 0-2).

**Energetic Particles / Solar Radiation:** GOES16 high energy (greater than 10MeV) proton flux remained at background levels. GOES16 high energy (greater than 2MeV) electron flux was moderate, peaking at 839pfu at 10/1720UTC. The 24-hour fluence was below the Active threshold (1e8 integrated pfu) on a slightly declining trend. The observation at 11/0000UTC was 4.03e7 integrated pfu.

**Four-Day Space Weather Forecast Summary**
**Solar Activity:** Low to Moderate activity is expected to continue, with a slightly decreasing likelihood of further isolated M-flares, predominately from AR3511 in the southwest or AR3513 in the north-centre disc.

**Solar Wind / Geomagnetic Activity:** A weak CME may give a glancing impact early on Day 1 (11 Dec), but this is very low confidence. Otherwise, an enhancement to slightly elevated or perhaps elevated wind speeds from either CH77/+ or CH80/+ is possible during Day 1 (11 Dec), although these are difficult to observe so confidence remains low. A decline in wind speeds is then probable through Days 2-3 (12-13 Dec). CH79/+, which is a new feature for this rotation, is then likely to become geoeffective sometime on Day 4 (14 Dec), potentially bringing elevated wind speeds.
Current Quiet geomagnetic activity may increase with the onset of any High Speed Stream (HSS) from CH77 or CH80 to become Unsettled with a risk of Active intervals, and a very slight chance of peak G1/Minor Storm conditions occurring. Activity then easing to become mainly Quiet once again, but with a similar increase in geomagnetic activity possible again on Day 4 with the onset of the HSS from CH79.

**Energetic Particles / Solar Radiation:** GOES16 high energy proton is expected to persist at

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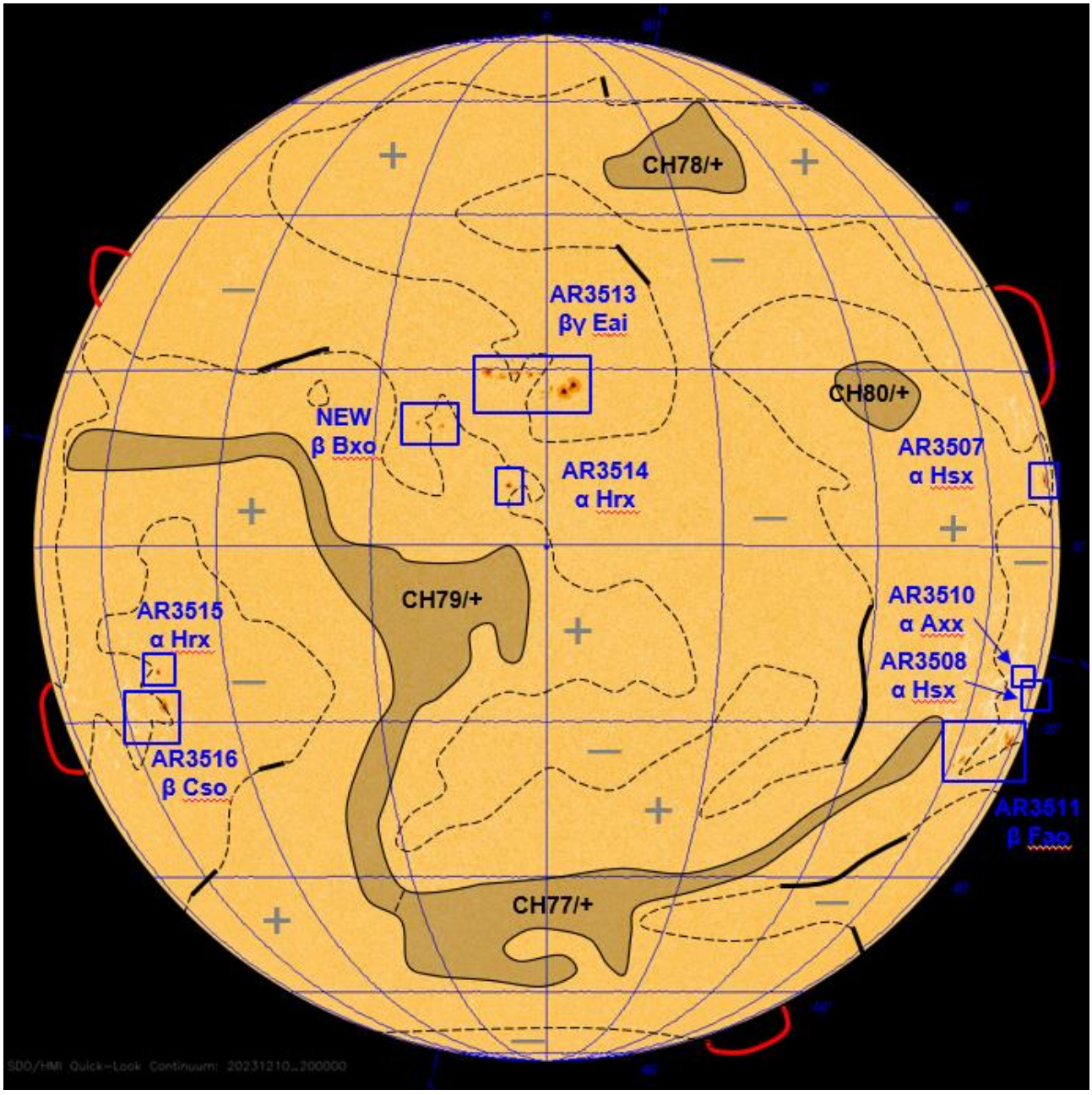
background levels, with only a very slight chance of rising towards the S1/Minor Radiation Storm level given any significant flares from AR3511 or perhaps AR3513. High energy electron flux is expected to be mainly moderate at first but dropping out with any CH or CME enhancements during Day 1 (11 Dec), before recovering to mainly moderate levels during the period. A further drop out is possible with another CH enhancement on Day 4 (14 Dec). The associated 24 hour fluence is expected to remain below the Active (1e8 integrated pfu) threshold.

**Figure 1. Solar Analysis Valid 10/2000 UTC.**




**Key:** Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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## Geomagnetic Storms:

There are no Earth-directed CMEs that are expected to have a significant influence on geomagnetic conditions, however there is a low confidence glancing impact possible early on Day 1 (11 Dec) from a CME which left the northeast disc after a filament eruption around 07/0200 UTC.

This CME may arrive alongside an enhancement to slightly elevated or perhaps elevated wind speeds either from the southern coronal hole CH77/+, or from the very small northwestern coronal hole CH80/+, likely during Day 1 (11 Dec). These are both now hard to see amongst other coronal loops in SDO imagery. This enhancement is indicated in Enlil modelling, however due to the obscured nature of the coronal holes confidence remains low. CH80/+ will likely pass quickly, while CH77/+ then becomes confined to more southerly latitudes, suggesting a decline in wind speeds through Days 2-3 (12-13 Dec). CH79/+, which is a new feature for this rotation, is then likely to become geoeffective sometime on Day 4 (14 Dec). Confidence is low in timing and peak wind speeds due to the non-persistent nature of this feature, but elevated wind speeds are once again possible.

Current Quiet geomagnetic activity may increase with the onset of any High Speed Stream (HSS) from CH77 or CH80 to become Unsettled with a risk of Active intervals, and a very slight chance of peak G1/Minor Storm conditions occurring. Activity then easing to become mainly Quiet once again, but with a similar increase in geomagnetic activity possible again on Day 4 with the onset of the HSS from CH79.

| Geo-Magnetic Storm Probability (Exceedance) | Level | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) (%) | Day 2 (00-24 UTC) (%) | Day 3 (00-24 UTC) (%) | Day 4 (00-24 UTC) (%) |
|---|---|---|---|---|---|---|
| Minor or Moderate | G1 to G2 | No | 5 | 1 | 1 | 5 |
| Strong | G3 | No | 1 | 1 | 1 | 1 |
| Severe | G4 | No | 1 | 1 | 1 | 1 |
| Extreme | G5 | No | 1 | 1 | 1 | 1 |

## Geomagnetic Activity - Earthbound Coronal Mass Ejections

| Date/time 21.5R (UTC) | Halo: Full or Partial | Source | Source Location | Estimated Speed | Estimated Arrival Time | Comments |
|---|---|---|---|---|---|---|
| 07/1302 | Nil | Filament | NE | 406 km/s | Early 11 Dec | Very low confidence glancing impact. |

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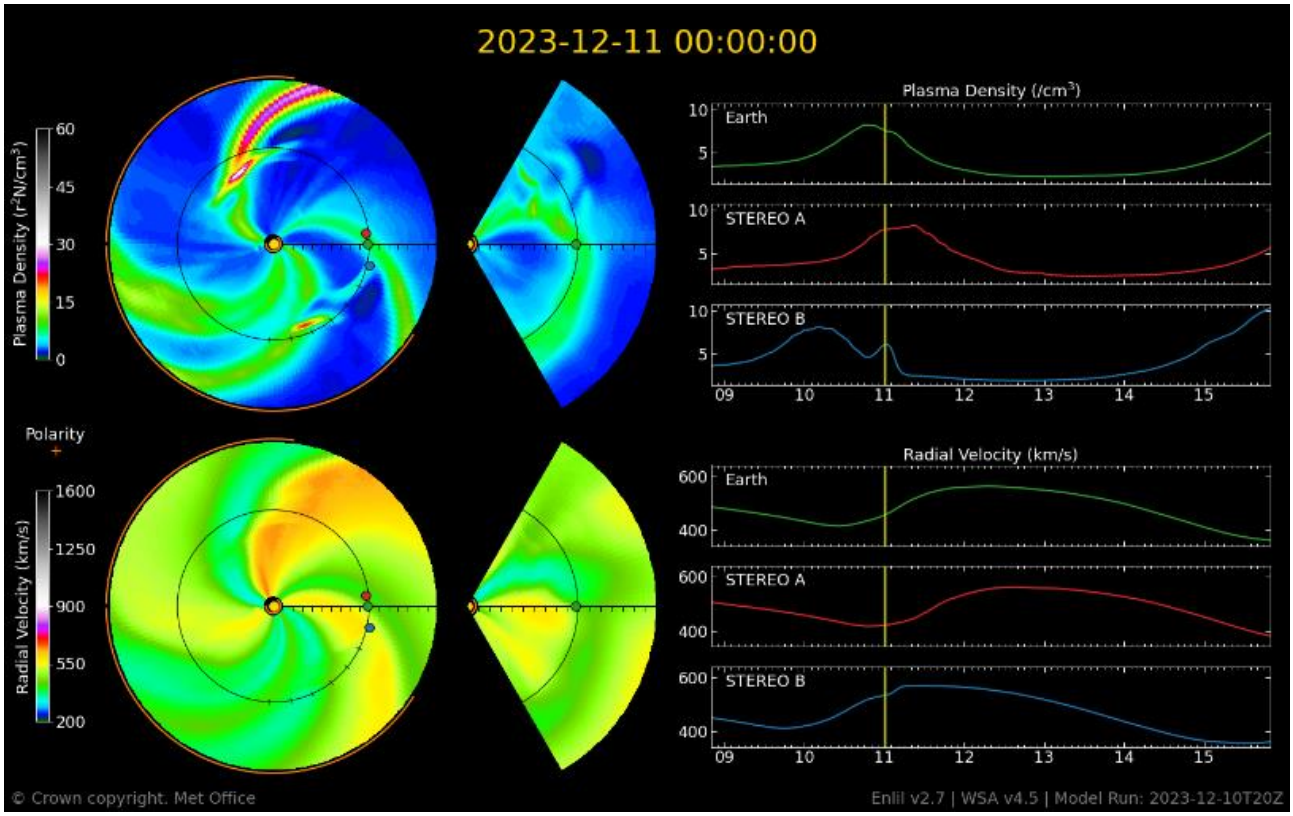
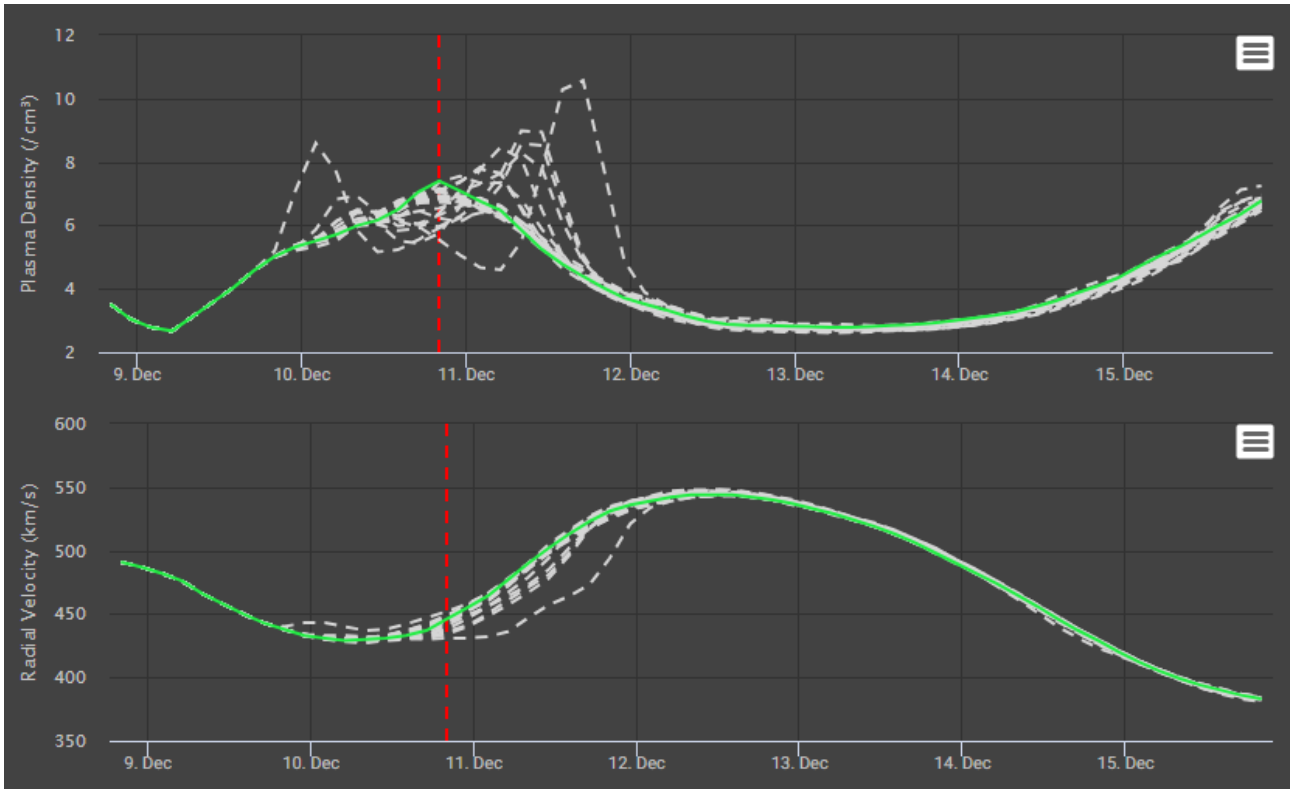
**Figure 2: MOSWOC Enlil and ensemble showing a likely HSS arrival during Day 1 (11 Dec), plus the risk of a CME glancing blow.**

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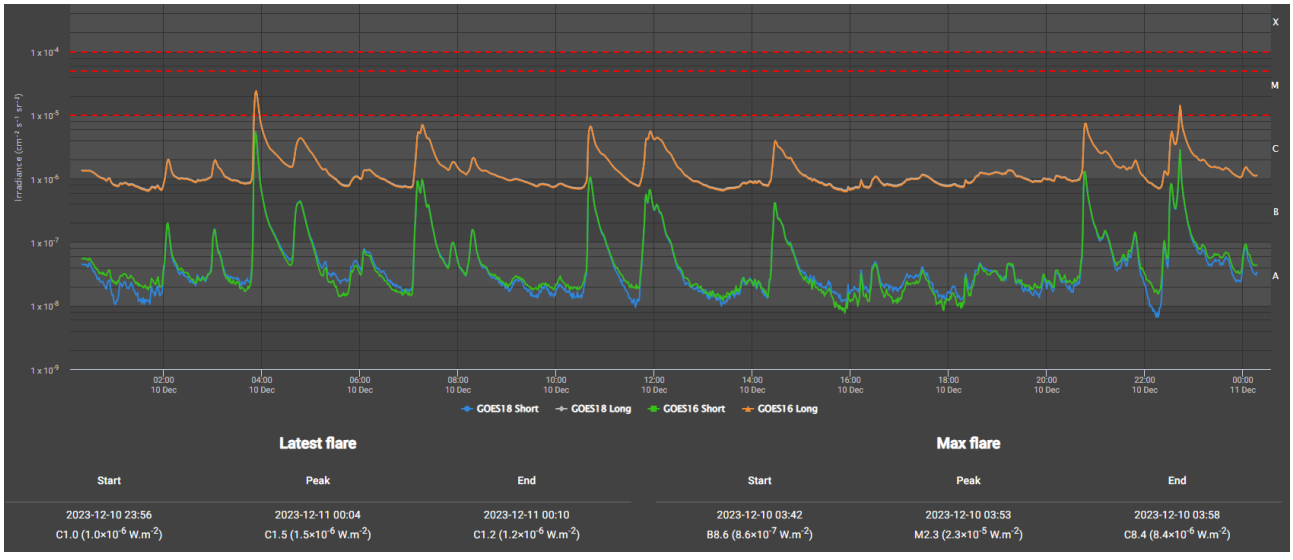
**Radio Blackouts - X-Ray Flares:**
Low to Moderate activity is expected to continue, with a slightly decreasing likelihood of further isolated M-flares.

There are currently nine sunspot regions on the disc, with one unnumbered region having faded and another developed. The most active region remains AR3511 (Fao/Beta), which is nearing the southwest limb and is becoming increasingly difficult to analyse. Although significant magnetic complexity can no longer be seen, there have been recent alterations in the shape of the leading spot and the activity level suggests more complexity than the current classification. AR3513 (Eai/Beta-Gamma) evolves slowly, with small changes in the numerous, mixed polarity spots that occupy the intermediate part of the group. All other regions are currently relatively small and simple at the present time.

AR3511 will rotate off the disc during Day 2 (12 Dec), with the flare risk reducing as this rotates away from the west limb. Whilst there is some indication of new regions to rotate onto the east limb in the coming days, there are currently no signs that any of these are significant regions.

| X Ray Flares | Level | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) | Day 2 (00-24 UTC) | Day 3 (00-24 UTC) | Day 4 (00-24 UTC) |
|---|---|---|---|---|---|---|
| Probability | | | (%) | (%) | (%) | (%) |
| Active | R1-R2 M Class | Yes | 60 | 60 | 50 | 40 |
| Very Active | R3 to R5 X Class | No | 5 | 5 | 5 | 5 |

**Figure 3: X-ray flux from GOES16 and GOES18.**

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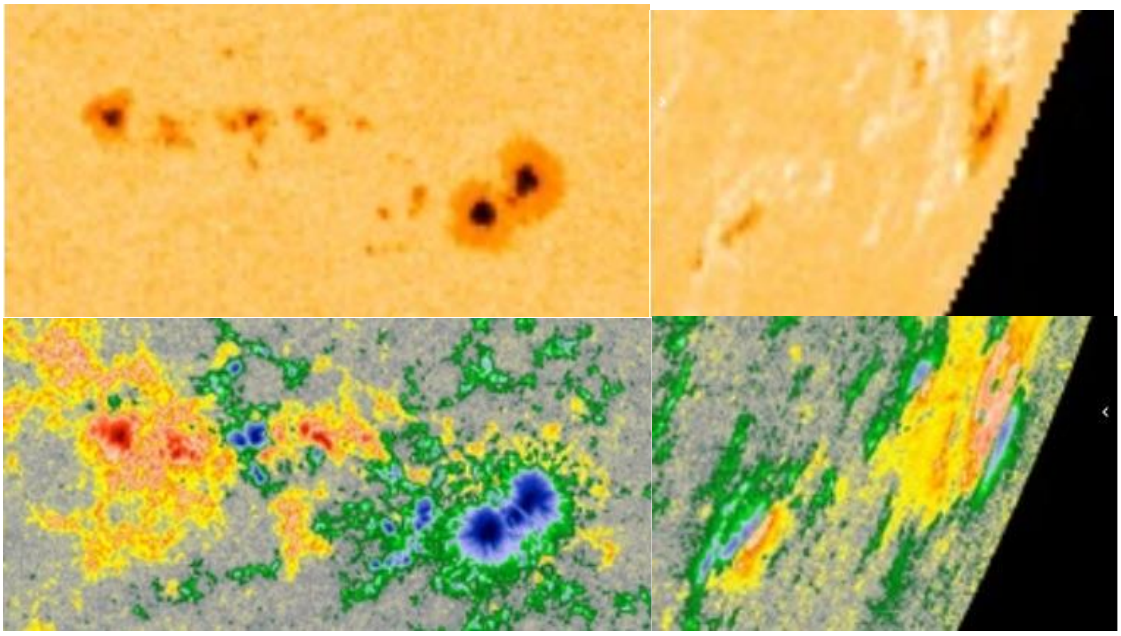
**Solar Radiation Storms - (High Energy Protons):**
The high energy (greater than 10MeV) proton flux observed by GOES16 is currently at background levels. There is a slight chance of this increasing should there be any significant flares on the disc, especially from AR3511 in the far southwest, and also from AR3513 as it moves into the western hemisphere. The risk reduces somewhat as AR3511 rotates away from the west limb after rotating off the disc during Day 2 (12 Dec).

| Radiation Storms Probability (Exceedance) | Level ($cm^{-2}$ $sr^{-1}$ $s^{-1}$) | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) (%) | Day 2 (00-24 UTC) (%) | Day 3 (00-24 UTC) (%) | Day 4 (00-24 UTC) (%) |
|---|---|---|---|---|---|---|
| **Active** | **≥ S1** | No | 10 | 10 | 5 | 5 |
| **Very Active** | **≥ S3 *** | No | 1 | 1 | 1 | 1 |
| * S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$) | | | | | | |

**Figure 4: SDO intensitygram and magnetogram from AR3513 (left) and AR3511 (right).**



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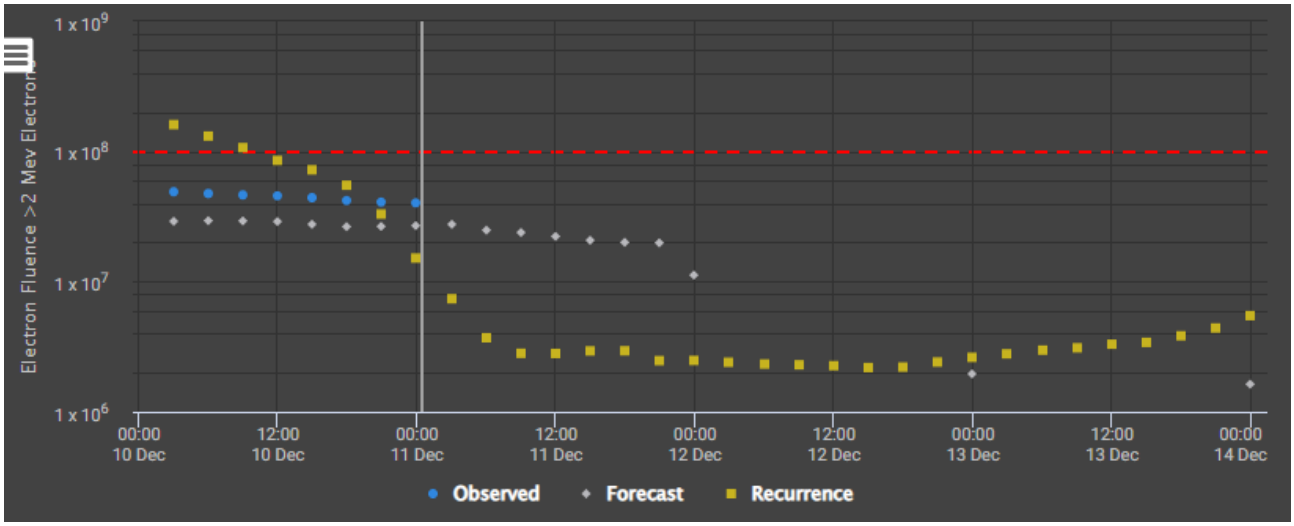
## High Energy Electrons Event (≥ 2MeV):

High energy electron flux, as observed by GOES-16, has been mainly moderate over the last few days, since the solar wind enhancement from a recent coronal hole. This is likely to drop to near background levels with any enhancement from either CH77/+ or CH80/+, along with any CME glance on Day 1 (11 Dec). Some recovery in flux, to mainly moderate levels, is then likely Days 2-3 (12-13 Dec), before a further suppression on Day 4 (14 Dec) with another enhancement likely from CH79/+.

The associated 24 hour fluence is expected to remain below the Active threshold through the period. A decline is probable on Day 1, before a slight recovery on Days 2-3. It is unlikely this will reach the Active threshold, however, before a further decline is likely on Day 4. This is broadly supported by REFM, which keeps fluence below Active, although doesn't really signal a rise on Days 2-3.

| GEO Electron Environment | Level ($cm^{-2}\ sr^{-1}\ day^{-1}$) | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) | Day 2 (00-24 UTC) | Day 3 (00-24 UTC) | Day 4 (00-24 UTC) |
|---|---|---|---|---|---|---|
| Probability (Exceedance) | | | (%) | (%) | (%) | (%) |
| Active | ≥ 2 MeV ≥ $1x10^8$ | No | 1 | 5 | 10 | 5 |
| Very Active | ≥ 2 MeV ≥ $1x10^9$ | No | 1 | 1 | 1 | 1 |

**Figure 5: MOSWOC REFM showing a below Active forecast.**

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